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Research Demonstrations of A New SF_6 Leak Sealing Concept

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Technical Update, March 2006

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3X Engineering and EDF

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1
INTRODUCTION

The purpose of this report is to summarize the field demonstrations of a new leak seal technique that EPRI has been researching in collaboration with EDF (France). The demonstration was successful – with three SF_6 leaks successfully sealed in three host utility sites.

The purpose of the research demonstrations is to evaluate the application method and the performance of this new technique. The field demonstrations are thus a starting point of research that will be focused on tracking the long-term performance of this solution. The utility research partners in the APO (Additional Project Opportunity) are:

- Duke Energy
- Consolidated Edison
- National Grid (UK)
- PSE&G
- TVA

The project research goal was to investigate new techniques for sealing SF_6 leaks that met the following requirements (as identified by the research partners):

- Provides an effective temporary seal of the leak (Temporary was defined as 5-10 years)
- Is easy to remove – with minimal damage to the original flange
- Can be applied while the gas compartments are at full pressure – and, where clearances allow, can be applied while the equipment is in service.
- Is cost effective,
- Can seal even large leak rates while the gas is leaking,

Through collaboration between EPRI and EDF a novel technique was researched to seal SF_6 leaks. The technique itself was developed in partnership between EDF and a Monaco-based company called 3X Engineering – that has extensive experience with sealing in the oil and water industries. The technique uses a patented 3X Engineering solution named REFLANGEKIT. Contact details for 3X Engineering are listed in Appendix A.

Under a collaborative agreement between EPRI and EDF, EDF shared results of their laboratory tests of the new SF_6 leak seal concept and the experience of the 20 previous leaks sealing existing in France. The tests demonstrated that the technique held promise. Field tests were conducted in France and the UK in Nuclear GIS Switchyards and Transmission GIS – with a total of 23 SF_6 flange seals demonstrated.

The next steps in the research are the actions reported in this report - and are as follows:

- ***Demonstration of the flange sealing technique in US substations***: This step allows for the first demonstration of this concept beyond the UK and Europe – and allows for hands-on evaluation of the technique –and its performance over time. The flange seal was demonstrated at Consolidated Edison.
- ***Demonstration of a porcelain-metal interface seal:*** This step is especially unique since a field demonstration of such an interface has not been done anywhere in the world. Extensive research has been done on smaller porcelain test samples – and predicts a high level of success. This step represents significant growth in knowledge of the technique's abilities – and allows us to evaluate the application and the performance over time. Two such demonstrations were performed – one at PSE&G and one at Duke Energy.

The EDF co-developer attended the demonstration on sites. EDF whishes to share and enlarge the feed back around this leak sealing technique.

2
SUMMARY OF TESTS PERFORMED

The research demonstrations were conducted in three utilities and on two different geometries (A metal/metal bolted flange and a porcelain/metal interface) as summarized below in Table 1. The demonstration was successful – in all three SF_6 leaks successfully sealed in the three host utility sites.

Table 1 - Summary of research demonstrations applied

Utility	Type of seal	Manufacturer and Model	Date Sealed
Consolidated Edison	345kV GIS Flange	345kV GIS – ITE	8/11/2005
PSE&G	230kV Dead-tank Breaker bottom flange	Westinghouse 2300SF17,500	10/11/2005
Duke Energy	500kV Live-tank Breaker bottom flange	Westinghouse 550SFA40	14/11/2005

In each case, the following general procedure was followed:

1. Based on the dimensions of the leaking component, a rigid plastic mould was made to encapsulate the leaking area.
2. In addition to the rigid outer mould, a flexible inner covering was also manufactured. The role of the inner flexible covering is to protect the flange and the bolts from the sealant – allowing for easy removal of the seal if the flange needs to be disassembled – and also allows for sealing of the leak while the leak is still present (i.e. without removing the gas or reducing the pressure).
3. The area above and below the leak seal location is cleaned and roughened to allow for effective adhesion of the sealant.
4. The soft inner shell and rigid outer shell are put in place and the sealant is poured into the rigid outer shell – forming the seal, while protecting the flange material from the resin.

The application differed slightly for each of the three research demonstrations. The next three chapters present graphically the specific steps taken at each of the utility sites.

3
CONSOLIDATED EDISON – 345KV GIS FLANGE

- The research demonstration at Consolidated Edison was conducted on a bolted flange on a 345kV GIS.
- The nominal pressure in the compartment was 30psi.
- A rough estimate of the leak rate was 30kg/year (66lbs/year)
- The leak was located be referring to past surveys conducted at the station with an SF_6 camera. The leak was then re-confirmed on site using a gas sniffer.
- The leak rate on the chosen flange was reduced slightly by tightening the bolts – but still present. The sealing was thus still necessary.
- The sealing was performed while the equipment was in service – with no impact on operations
- The seal is predominantly resin and plastic and is thus places a low mechanical loading on the GIS.
- The leak seal took approximately 5 working hours to complete and spanned two consecutive days
  - ***First Day***: Surface preparation, shell positioning, first pouring of sealant, curing of first pouring of the sealant (4 hours)
  - ***Second Day***: Final pouring of the sealant to complete the mould (1 hour)
- ***The leak seal was successful – with no leaks detectable by the SF_6 sniffer.***

Next Steps:

- The next step in the research is to examine this seal with a gas sniffer every 6 months to confirm that the leak is still sealed.
- There is interest in possibly expanding the technique to seal oil leaks and by-pass piping.

The step-by-step application of the technique is described overleaf in Table 2.

Table 2: Consolidated Edison Application

	
Step 1: Surface Preparation	Step 2: Application of the inner flexible shell
	
Step 3: Application of the outer rigid shell	Step 4: Application of the sealing resin
	
Step 5: Final leak detection to prove the seal	Step 6: Seal complete

4
PSE&G – OUTDOOR 230KV DEAD-TANK BREAKER

- The research demonstration at PSE&G was conducted on a porcelain/metal interface at the base of the bushing on an outdoor dead-tank 230kV circuit breaker.
- A rough estimate of the leak rate was 300-500kg/year (660-1100lbs/year). Even this very large flow-rate could be sealed while the leak was present.
- Prior to the leak sealing, the leak was located using an LIS (Laser imaging Systems) GasVue TG-30 V2 SF_6 camera applied by PSE&G – as shown in Figure 1.

Figure 1 - Application of the GasVue camera for location of the SF_6 leaks

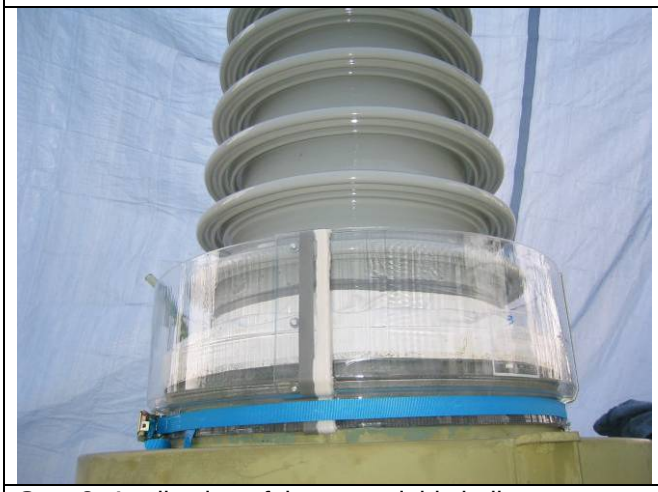
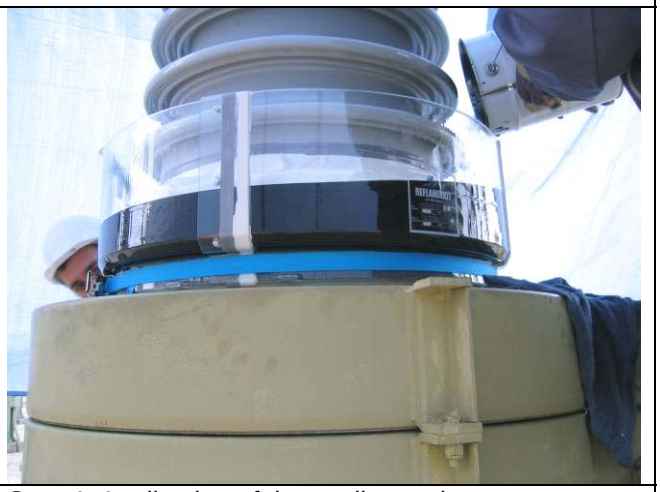
- The leak seal took 7 working hours to complete and spanned two consecutive days
  - ***First Day***: Surface preparation, shell positioning, first pouring of sealant, curing of first pouring of the sealant (6 hours). The ambient temperature was far colder than the prior application at Consolidated Edison – and that colder temperature slows the curing time of the resin. Hence the comparatively longer working hours.
  - ***Second Day***: Final pouring of the sealant to complete the mould (1 hour)
- ***The leak seal was successful – with no leaks detectable in the sealed area.***

Next Steps:

- The application on a porcelain interface extends the research – and there is keen interest to evaluate the performance of the seal. The next step in the research is thus to examine this seal with a gas sniffer every 6 months to confirm that the leak is still sealed.
- The breaker is located in a part of the country that exhibits large swings in temperature. The application is thus very useful to evaluate the effectiveness of the sealing approach under these extreme environmental conditions

The step-by-step application of the technique is described overleaf in Table 3.

Table 3: PSE&G Application

	
Step 1: Surface Preparation	Step 2: Application of the inner flexible shell
	
Step 3: Application of the outer rigid shell	Step 4: Application of the sealing resin
	
Step 5: Final leak detection to prove the seal	Step 6: Seal complete

5
DUKE ENERGY – OUTDOOR 500KV LIVE-TANK BREAKER

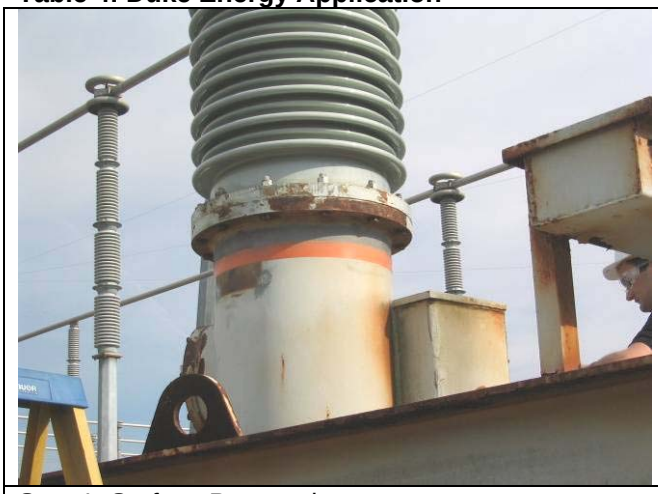
- The research demonstration at Duke Energy was conducted on a porcelain/metal interface at the base of the bushing on an outdoor live-tank 550kV circuit breaker.
- A rough estimate of the leak rate was 300-500kg/year (660-1100lbs/year). Even this very large flow-rate could be sealed while the leak was present.
- A driver for the application was that the leak seal approach seals no only the porcelain/metal interface – but also the bolted flange below. Duke Energy have found that once the porcelain/metal flange is sealed, the leak commonly migrates to the flange below – hence a seal that seals all those sites simultaneously is attractive.
- The leak seal took approximately 5 working hours to complete and was completed in one day.
  - ***First Day***: Surface preparation, shell positioning, first pouring of sealant, curing of first pouring of the sealant (6 hours). Final pouring of the sealant to complete the mould (1 hour). The ambient temperature was far warmer than the prior application at PSE&G – and that warmer temperature accelerates the curing time of the resin. Hence the ability to complete the leak seal in one day.
  - ***No Second day needed***
- ***The leak seal was successful – with no leaks detectable in the sealed area by the SF_6 sniffer.***

Next Steps:

- The application on a porcelain interface extends the research – and there is keen interest to evaluate the performance of the seal. The next step in the research is thus to examine this seal with a gas sniffer every 6 months to confirm that the leak is still sealed.
- The 550kV circuit breaker exhibits a significant amount of movement at the location of the seal when the breaker operates. The application is thus very useful to evaluate the effectiveness of the sealing approach under these high mechanical loads.

The step-by-step application of the technique is described overleaf in Table 4.

Table 4: Duke Energy Application

	
Step 1: Surface Preparation	Step 2: Application of the inner flexible shell
	
Step 3: Application of the outer rigid shell	Step 4: Application of the sealing resin
	
Step 5: Final leak detection to prove the seal	Step 6: Seal complete

6
FUTURE RESEARCH – NEXT STEPS

The immediate objective of sealing each of the three leaks was successfully achieved in each of the host sites. The next step is close scrutiny of the application performance over time:

- Due to its geographic location, the PSE&G application will allow for examination of how the technique will perform through wide variations in temperature.
- Due to the type of breaker, the Duke application will allow for examination of how the technique performs under large mechanical loads exhibited during breaker switching.
- The Consolidated Edison application on a GIS flange will allow for investigation on the merits if the technique for further GIS applications.

The future research will thus keep track of the effectiveness of the seals over time – and attempt to relate any failure of the seals to an underlying cause.

EDF and RTE have decided to expand the application of this solution to its maintenance teams as an alternative technique to seal the SF_6 leaks.

Appendix A details the contractor

Appendix B details the removal procedure of the seal.

A
APPENDIX – CONTRACTOR DETAILS

The information of the company performing the leak seals is as follows:

3X ENGINEERING

9 av. du Prince Héréditaire Albert

98000 MONACO

Tel number : 00.377.92.05.79.81

Fax number : 00.377.92.05.72.71

Contact : Stanislas BOULET D'AURIA

(Chairman & Managing Director)

email address : sbda@3xeng.com

website : www.3xengineering.com

B
APPENDIX – SEALANT REMOVAL TECHNIQUE

REFLANGEKIT REMOVAL PROCEDURE

APLLICATION TO: CIRCUIT BREAKER

INTRODUCTION

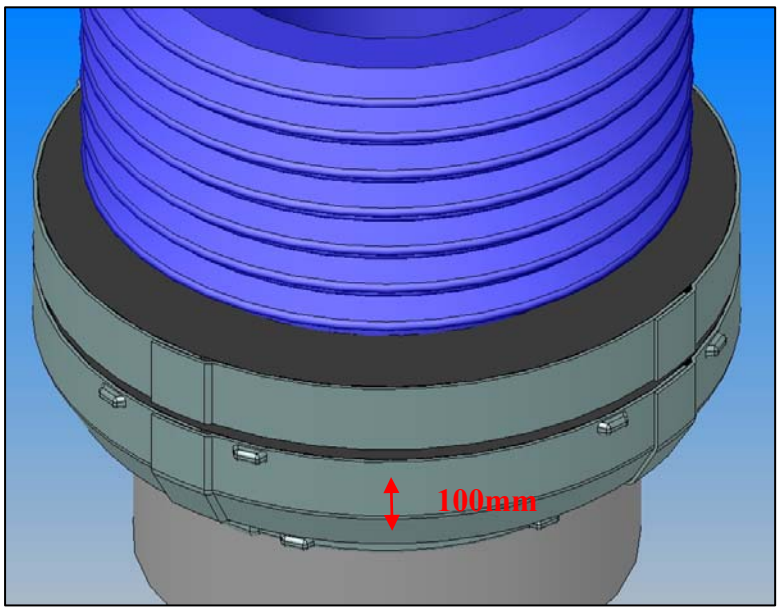
The REFLANGEKIT is a new leak sealing technique for GIS and circuit breakers. This concept has been developed to be rapidly and simply applied but also easily removable.
One of the main advantages is based on its double shell concept. Indeed, it protects the screw and bolts from the resin and enables to be removed without damaging the installation.

CAUTION:

In order to insure the good quality of the operation, please respect carefully all following steps of the process.

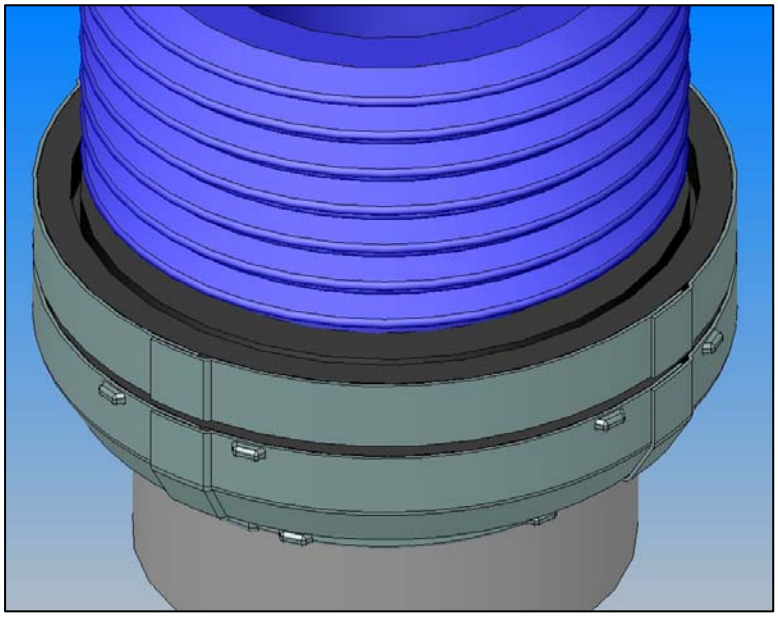
N.LEGRAND
15th December 2005

STEP 1: CUT THE RESIN



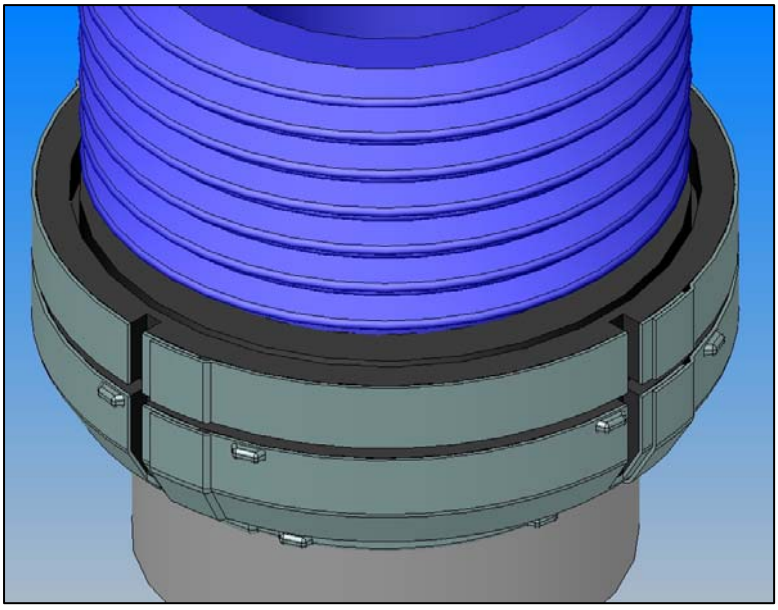
Use an angle grinder in order to cut the resin and the formwork in the circular way all around the breaker, 100mm below the top of the resin level. (As shown in the figure 1).
Cut the sleeve until you reach the white soft cover

Figure 1



Then, use a drilling machine (such as a DREMEL® coupled with cutting bit) and cut smoothly the top part of the resin as indicate on the figure n°2.
Take care to not deteriorate the ceramic part.

Figure 2



Use an angle grinder and cut the resin and the formwork in four pieces.

Figure 3

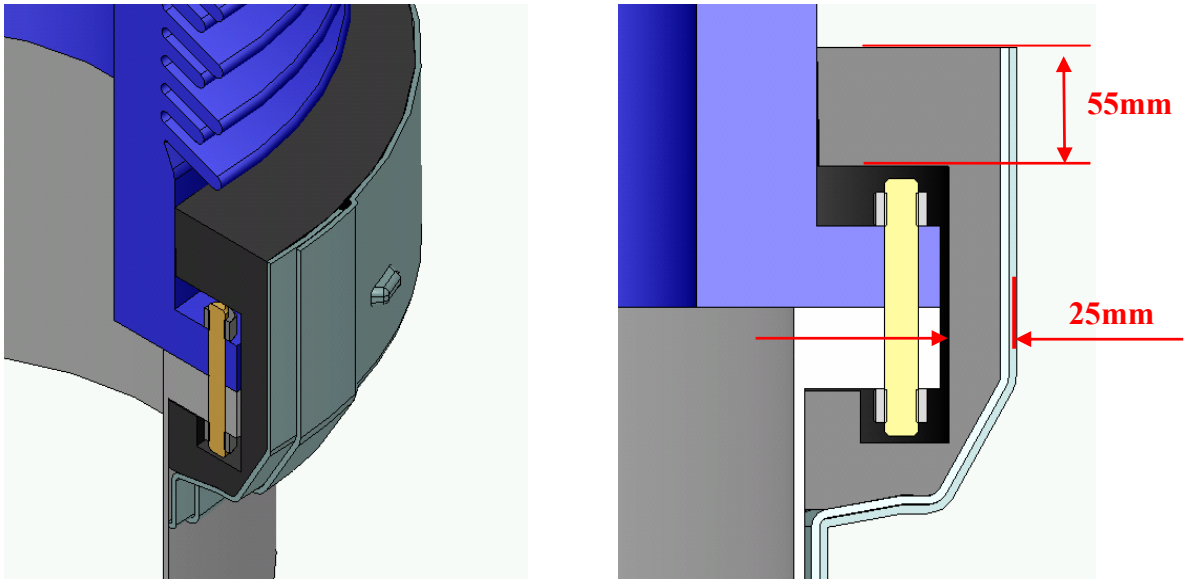
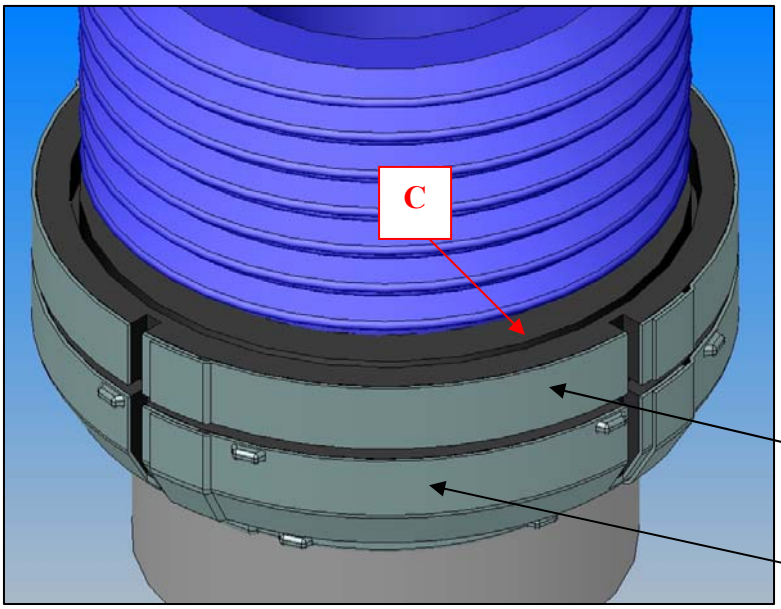


Figure 4

WARNING: Do not cut deeper than the dimensions indicated figure 4 otherwise you would damage the installation.

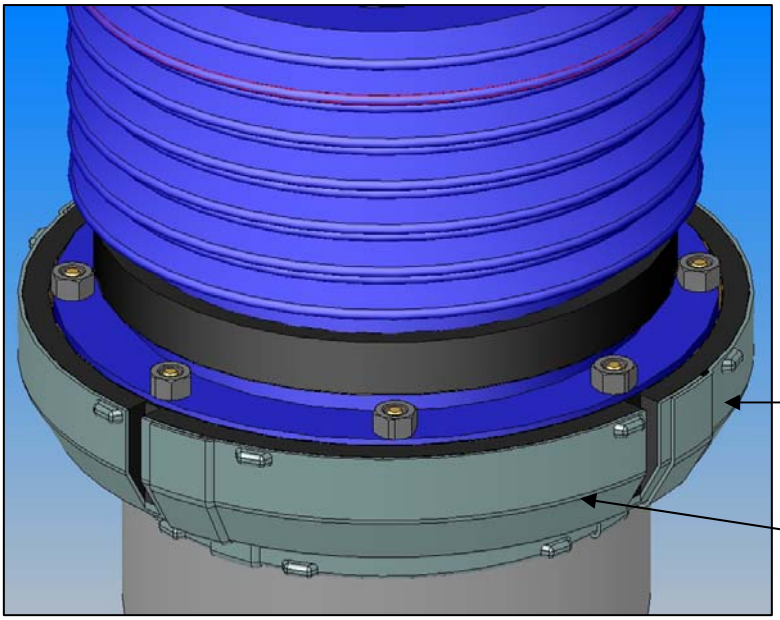
STEP 2: BREAK THE RESIN



Insert a nail claw between the part A and the part B of the resin in order to break the junction and remove the part A all around the breaker.

Figure 5

CAUTION: Do not exert any forces or stresses on the part stuck to the porcelain (part C).



Again, insert the nail claw between the part B1 and the flange to remove the part bonded on the pipe. Repeat the step three times with the other parts.

Figure 6

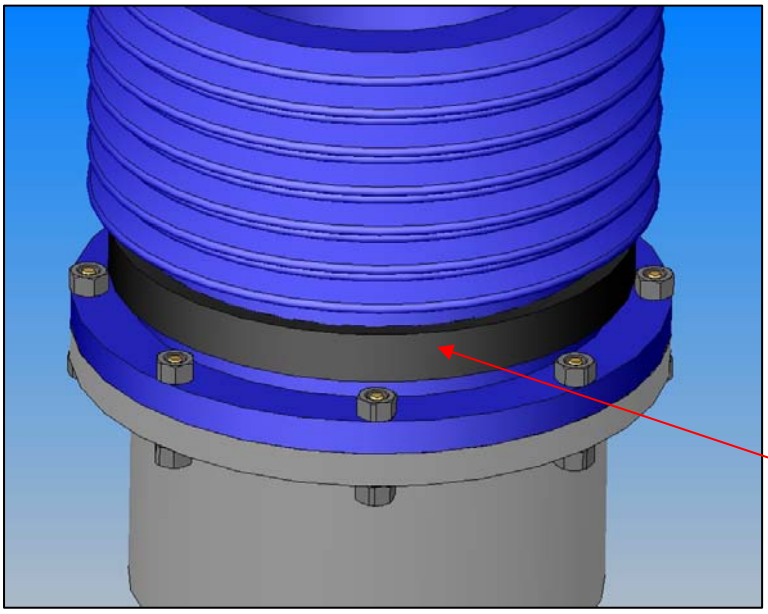


Figure 7

The final part C could be leaved on the porcelain to protect the seal or removed using a rotary tool with sandpaper.

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